

**Taxonomic Review of the Genus *Diaphanosoma*  
(Branchiopoda, Ctenopoda, Sididae), with a Redescription of  
*Diaphanosoma dubium* in Korea**

**Seong Myeong Yoon\* and Won Kim**

(\*Department of Biology Education, College of Education, Chosun University,  
Kwangju 501-759, Korea; Department of Molecular Biology,  
College of Natural Sciences, Seoul National University, Seoul 151-742, Korea)

**ABSTRACT**

*Diaphanosoma dubium* Manuilova, frequently confused with the species group of *D. brachyurum* Lieven and misidentified as an invalid species of *D. leuchtenbergianum* Fischer in the Far East, was redescribed and illustrated. Redescription was based on the materials collected from various freshwater habitats at 76 localities in South Korea during the period from May 1978 to June 1999. Previous records of *Diaphanosoma* species from Korea were examined. *D. dubium* is well distinguished from other related species by having large head, longer swimming antennae with a thin seta on the outer distal side of basipod, carapace lacking dorsal spine at the posterior carapace margin, and fewer denticles on the ventro-posterior carapace margin.

Key words: Taxonomic review, redescription, *Diaphanosoma dubium*, Korea

**INTRODUCTION**

Since Frey (1973) introduced new methods and the first serious evaluation of the theory of cosmopolitanism in the cladoceran classification, a lot of vigorous studies to reexamine previous works have been performed over various cladoceran taxa. It has been shown that many previous

---

\*To whom correspondence should be addressed.

descriptions often concerned either species complexes or intraspecific units, and is believed that most described species needed revision (see Korovchinsky, 1996).

Recently several species were redescribed and revised in the genus *Diaphanosoma* Fischer (Korinek, 1987; Korovchinsky, 1992, 1995, 1998). New species were described by the reexamination of previous works and materials (Korovchinsky, 1998; Korovchinsky and Mirabdullaev, 1995). Through these studies a lot of older species were synonymized and regarded as the invalid ones, and some were turned out to be the species groups. Presently about 25 species of the genus are known as the valid ones in the world (Korovchinsky, 1992, 1996, 1998; Korovchinsky and Mirabdullaev, 1995).

In the Far East total six *Diaphanosoma* species were recorded from Far Eastern China (Chiang and Du, 1979), Far Eastern Russia (Manuilova, 1964), Japan (Ueno, 1927; Mizuno and Takahashi, 1991), and Korea (Yoon and Kim, 1987; Kim, 1988). Among them invalid records of two species, *D. brachyurum* (Lieven, 1848) and *D. leuchtenbergianum* Fischer, 1850, were included in the present point of view (Korovchinsky, 1992, 1996). Most of all the previous works were lacking precise descriptions and detailed drawings of the species, insufficient to tell their status exactly. The Far Eastern *Diaphanosoma* is therefore in need of the reinvestigation including the redescriptions of older taxa.

When studying cladoceran fauna, the senior author of the present study found out that *D. dubium* Manuilova, 1964 was widely distributed in Korea. The species had not been recorded from Korea. He also became aware that most records of *D. brachyurum* and *D. leuchtenbergianum* in the Far East were probably the erroneous ones of *D. dubium*. In the present paper *D. dubium* from Korea is redescribed, and the taxonomy of the genus *Diaphanosoma* in the Far East is discussed.

## MATERIALS AND METHODS

Materials of *Diaphanosoma* were collected from the various freshwater habitats such as lakes, rivers, streams, and reservoirs of 76 localities in south Korea during the period from May 1978 to June 1999 (Fig. 1). Collections were made with a conical plankton net (155  $\mu$ m in mesh size). Samples were fixed with 10% formalin, and preserved in 4% formalin.

The samples were inventoried to determine the presence and the reproductive state of the species under a Olympus stereomicroscope. Each specimen was removed to a drop of glycerol in a reversed slide for subsequent study. Temporary mounts of whole specimens in glycerol were used for the measurements and the drawings of intact animals and their parts. Whole bodies were dissected with tungsten needles to examine antennae, carapaces, postabdomens, postabdominal claws, and other parts. Drawing and measuring were made with a Olympus compound microscope with a drawing tube system. All specimens examined are deposited in the senior author's collection.

More than 20 parthenogenetic female specimens were examined in each of all the samples collected from 76 localities of the present study. The appendix includes the station number, its locality and other informations. Collectors were not referred when the specimens were collected by

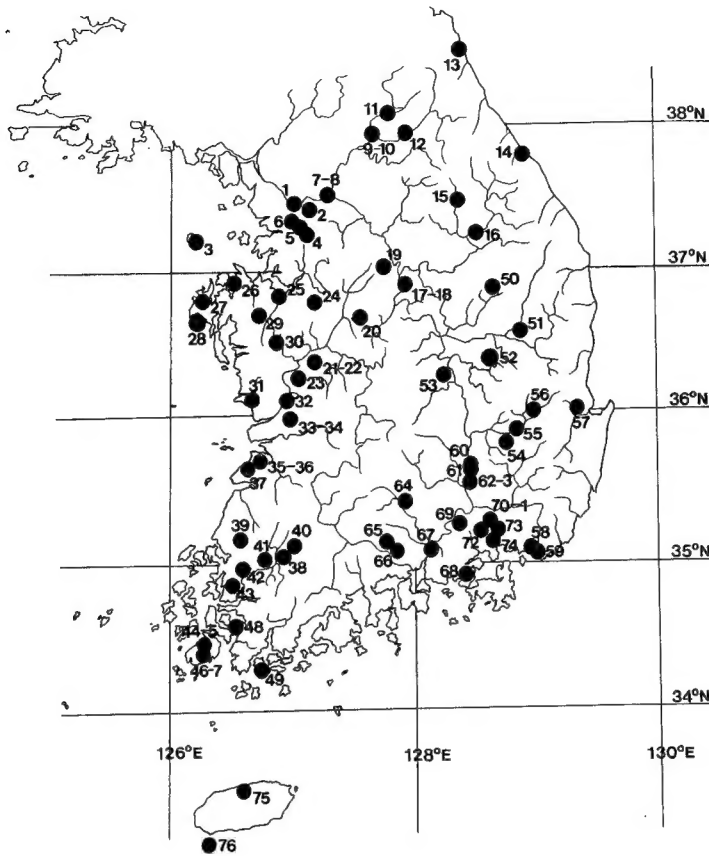


Fig. 1. Localities from which the specimens were collected.

the authors themselves.

## RESULTS AND DISCUSSION

### Redescription of species

#### *Diaphanosoma dubium* Manuilova, 1964 emend. Korovchinsky and Mirabdullaev, 1994 (Fig. 2)

*Diaphanosoma brachyurum* var. *leuchtenbergianum* (non Fischer, 1850): Ueno, 1927, p. 274.

*Diaphanosoma brachyurum* (non Lieven, 1848): Chiang and Du, 1979, p. 87, Fig. 57; Yoon and Kim, 1987, p. 179, Fig. 2f; Kim, 1988, p. 53, fig. 2; Mizuno and Takahashi, 1991, p. 131.

*Diaphanosoma leuchtenbergianum* (non Fischer, 1850): Chiang and Du, 1979, p. 90, Fig. 60; Yoon and Kim, 1987, p. 179, Fig. 2g-i; Kim, 1988, p. 53, fig. 3.

*Diaphanosoma dubia* Manuilova, 1964, p. 110, Fig. 28; Korinek, 1987, p. 38, Figs. 15-34; Korovchinsky, 1992, p. 42, Figs. 198-202.

*Diaphanosoma dubium*: Korovchinsky, 1998, p. 114, Figs. 30-35.

**Material examined.** Numerous specimens of parthenogenetic females collected from every 76 localities listed in the 'Appendix'.

**Parthenogenetic female.** General shape (Fig. 2a): Body somewhat bilaterally compressed, peanut-shaped with large head in outline of lateral view. Head distinctly separated from body. Antennules small, arising ventrally from midway of ventral margin of head. Antennae very large; distal ends reaching to posterior margin of carapace, often projecting posteriorly out. Color hyaline, yellowish or milky.

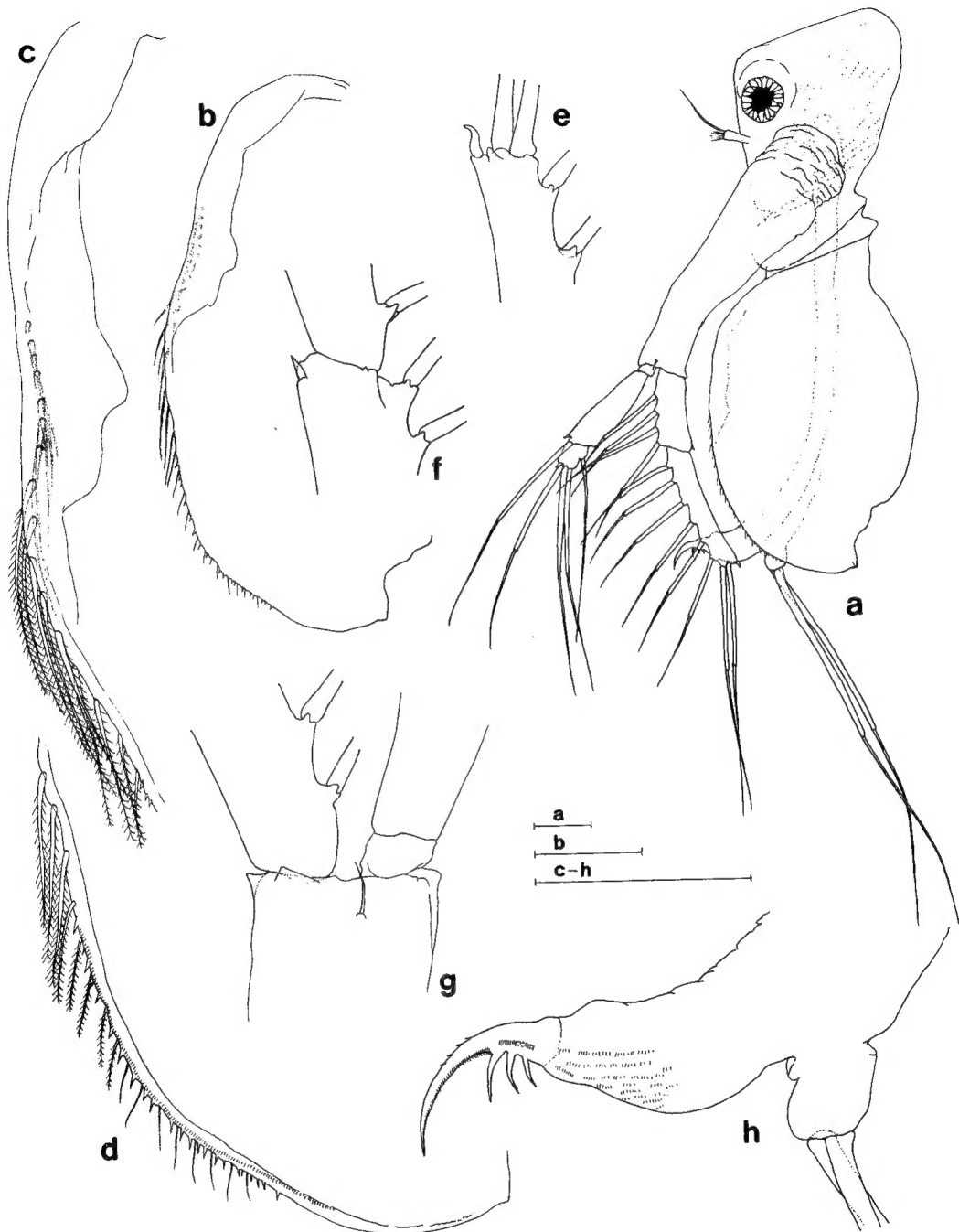
Head (Fig. 2a): Very large, dorsal part strongly protruding; length nearly equal to carapace length. Marking absent. Anterior, dorsal and ventral margins nearly straight; length of dorsal margin longer than that of ventral; width decreasing conspicuously into proximal part. Both anterior dorsal and ventral corners rounded. Eye large, shifted ventrally and filling apart in short distance from anterior margin. Proximal part near border with body forming 1-2 deep notch.

Carapace (Figs. 2a-d): Oval in lateral view, thin and without any marking. Dorsal margin arched in middle, smoothly connected anteriorly to that of head shield, and distinctly indented near posterior end forming prominent posterior shell angle with posterior part of ventral margin. Ventral margin evenly curved, with large ventral inflexion on anterior half followed by row of denticles and thin setules arranged along posterior half (Fig. 2b); ventral inflexion not shifted proximally, bearing 14-16 long feathered setae arranged along margin; proximal ones of these setae shorter and passing on internal side of inflexion, and distal ones situated on lower part of postero-ventral margin (Figs. 2b, 2c). Posterior half of ventral margin provided with row of 20-31 (usually about 24) denticles accompanied by row of minute supramarginal spinules along inner side of margin; anterior denticles somewhat larger than posterior, and their number usually differing on both shells; row of denticles subdivided into unsharply delineated groups by 1-3 denticles with 10-14 thin setules between them; 3-5 setules located on anteriormost part finely haired, but situation of remaining ones indistinct (Fig. 2d). Posterior margin without dorsal spine and any ornamentation (Figs. 2b, 2d).

Antenna (Figs. 2a, 2e-g): Long and massive, longer than 3/4 of body length. Antennal formula 4(1)-8(1)/0(0)-1(1)-4(1); lateral setae on proximal and distal segment of 2-branched exopod shorter than distal setae on distal segment of exopod (Fig. 2a); setae on 3-branched endopod nearly equal in length; all distal spines except that on distal segment of exopod, which comparatively large and noticeably curved, subequal in size and shape of general form (Figs. 2e, 2f); approximate length ratios of exopod segments relative to basipod length 0.28 and 0.38, endopod segments 0.03, 0.33, and 0.09. Basipod with comparatively long seta tapering distally on middle of outer lateral surface near distal end, and with small dorsal outgrowth on distal end near base of antennal exopod (Fig. 2g). Distal ends of proximal and distal segments of antennal exopod having small outgrowth; outgrowth on proximal segment often rudimentary, much smaller than that on distal segment. Surface nearly not ornamented.

Trunk limbs: Six trunk limbs of general forms of genus (figures not given).

Postabdomen (Fig. 2h): Small, tapering into postabdominal claw; dorsal margin somewhat prominent in middle and strongly depressed proximally near base of abdominal setae; ventral margin slightly expanded on distal part near base of postabdominal claw. Abdominal setae very



**Fig. 2.** *Diaphanosoma dubium* Manuilova, lateral view of parthenogenetic female. a, habitus; b, carapace, outer view; c, anterior part of ventral margin of carapace; d, posterior part of ventral margin of carapace; e, distal segment of antennal exopod; f, proximal segment of antennal exopod; g, basipod of antenna; h, postabdomen. Scales: 0.1 mm for all.

long, slightly shorter than antenna, arising from robust cylindrical base at antero-dorsal corner. Dorsal and dorso-lateral surface ornamented distally with groups of very fine spinules forming several rows disrupted occasionally.

Postabdominal claw (Fig. 2h): Large, bent dorsally at about proximal 2/3 of length, and possessing 3 comparatively strong basal spines; basal spines somewhat curved toward proximally, curvature more strong at distal spine. Dorsal margin from base of distal basal spine to tip having row of minute spinules arranged along dorsal edge, and with short row of fine spinules arranged along submarginal region of basal spines. Ventral margin possessing 4-5 minute spinules along midway of ventral edge.

**Ephippial female and male.** Not found from Korea.

**Size.** Length range (from anteriormost part of head to posteriormost part of carapace) of mature parthenogenetic females 0.61-1.24 mm.

**Remarks.** This species was usually recorded under the name of *D. brachyurum* Lieven or *D. leuchtenbergianum* Fischer in the Far East (Ueno, 1927; Chiang and Du, 1979; Yoon and Kim, 1987; Kim, 1988; Mizuno and Takahashi, 1991). Though most previous descriptions and drawings are short and insufficient to tell the real status of the materials, they make it possible to recognize the species from diagnostic features such as the massive and protruding head, the large and long antenna, and the ornamentation and structure of the ventral to posterior margin of carapace. •

**Distribution.** Far East (Amur river of Russia, Korea, East of China, Japan), East of Mongolia, Malaysia, and Bangladesh.

### Review of taxonomy

In Korea, only *D. brachyurum* Lieven had long been recorded as a *Daphanosoma* species through several limnological studies without any taxonomic considerations since the first report by Ueno (1941). Yoon and Kim (1987) first described Korean populations of two species, *D. brachyurum* Lieven and *D. leuchtenbergianum* Fischer, and Kim (1988) presented the taxonomic key for Korean cladocerans including additional species, *D. sarsi* Richard. After these further study has not been made, presently total three *Diaphanosoma* species are reported in Korea. Among them, *D. brachyurum* and *D. leuchtenbergianum* are known to be common and widely distributed while *D. sarsi* is very rare and restricted to brackish water in Korea (Yoon and Kim, 1987; Kim, 1988). *D. brachyurum* and *D. sarsi* are also recorded from China and Japan, and *D. leuchtenbergianum* from China in the Far East (Chiang and Du, 1979; Mizuno and Takahashi, 1991).

Because based on the theory of cosmopolitanism, previous works in Korea were not made carefully and including many erroneous informations as those in other countries were (see Korovchinsky and Mirabdullaev, 1995). Recently it was proved that many *Diaphanosoma* species had been incorrectly described under different names and a lot of different species were erroneously recorded under the same name in the world (Korinek, 1987; Korovchinsky, 1992, 1995, 1998; Korovchinsky and Mirabdullaev, 1995). Among three species recorded in Korea, *D. leuchtenbergianum* and *D. brachyurum* are now regarded as an invalid species and the species groups, respectively (Korovchinsky, 1992, 1996). Especially *D. brachyurum* has long been known as the representative of world-widely distributed species, but it's practical geographic range seems

to be restricted to the palaearctic region from Europe to Central Asia (Korovchinsky, 1992). So the previous reports of the two *Diaphanosoma* species from the Far East including Korea are questionable and unsubstantiated.

Only a few characters such as the shape of the ventral inflexion of carapace, the ornamentation of the ventral margin of carapace, and the length of antenna have been used for discriminating *Diaphanosoma* species in the Far East (Chiang and Du, 1979; Yoon and Kim, 1987; Mizuno and Takahashi, 1991). All the previous descriptions and drawings were very short and somewhat doubtful, and overlooked some important characteristic features found on the antennal basipod, endopod and exopod in the present point of view. Such problems included in the monograph of China (Chiang and Du, 1979), the representative work in this region, were recently pointed out by several authors (Korinek, 1987; Korovchinsky and Mirabdullaev, 1995). Though having insufficient informations, the previous reports show that both the species recorded as *D. leuchtenbergianum* and *D. brachyurum* have a remarkable characteristic feature of large head with strongly protruding dorsal part. Also the two species could not be distinguishable from each other in any parts of descriptions and drawings except in the difference of antennal length (Ueno, 1927; Chiang and Du, 1979; Yoon and Kim, 1987; Kim, 1988; Mizuno and Takahashi, 1991). So, there is a high possibility that the two species were the same one.

In the present study, the authors examined Korean *Diaphanosoma* materials having the large head with strongly protruding dorsal part. The materials included a part of previous authors' specimens that had been discriminated into two different species (Yoon and Kim, 1987; Kim, 1988). They superficially seemed to be composed of two different groups in the length of antenna, but any other distinguishable features between the two were not found. All the materials were eventually turned out to be *D. dubium* Manuilova. This result is to reveal that previous records of both *D. brachyurum* and *D. leuchtenbergianum* are erroneous ones of *D. dubium* in Korea.

*Diaphanosoma dubium* was first described from the Amur river in Russian Far East by Manuilova (1964). It was characterized by the large head with strongly protruding dorsal part and the carapace with numerous uniform denticles and long setules along the ventro-posterior margins in the original description (Manuilova, 1964). After the first description, *D. dubium* had not been reported elsewhere until Korinek's (1987) study, so it was believed to be rare and having narrow distribution range for a while. Korinek (1987) redescribed the species, and pointed out the wide distribution with synonymizing several previous records of *D. brachyurum* and *D. leuchtenbergianum* in China. Subsequently the occurrence in Topical Asia was known (Korovchinsky, 1992, 1998).

*Diaphanosoma dubium* belongs to the *Diaphanosoma modigliani*-*Diaphanosoma dubium* species group, which is characterized by strongly protruding head, together with *D. modigliani* Richard, 1894 and *D. tropicum* Korovchinsky, 1998 (Korovchinsky, 1998). Among three species, *D. dubium* seems to occur widely over Tropical Asia and East Asia while other two species to be restricted to Tropical Asia (Korovchinsky, 1992, 1998). Diagnostic features of *D. dubium* are presently known as follows: (1) head is large with greatly developed dorsal part, (2) eye is shifted ventrally, (3) swimming antenna is very long and possessing a small sharp spine (or a thin seta) on the outer distal side of basipod, a curved apical spine on the distal segment of exopod, (4) denticles of the ventro-posterior carapace margin are comparatively large in size and small in number, (5)

distal part of carapace is lacking the posterior spine, and (6) postabdomen has a prominent dorsal side. However, a larger parts of above features are common in both *D. modigliani* and *D. tropicum* (Korinek, 1987; Korovchinsky, 1992, 1998).

*D. dubium* is easily distinguishable from most of its congeners by the large head with distinctly protruding dorsal part. Among the species of the *Diaphanosoma modigliani*-*Diaphanosoma dubium* species group, *D. dubium* especially has close resemblances with *D. tropicum*. But it differs from *D. tropicum* by more massive head and relatively longer swimming antennae having a larger spine on the end of proximal segment of the antennal exopod. Also it can be distinguished from *D. tropicum* by less numerous, smaller and more sparsely distributed marginal denticles on the ventro-posterior part of carapace (Korovchinsky, 1998). On the other hand, *D. dubium* is differentiated from *D. modigliani* by larger head, longer antenna with a strongly curved spine on the end of distal segment of antennal exopod, comparatively long and not proximally shifted ventral inflexion of the carapace, fewer denticles on the ventro-posterior margin of carapace, and dorsally prominent postabdomen with relatively long postabdominal spines (Korinek, 1987; Korovchinsky, 1992, 1998). Among diagnostic features of *D. dubium* mentioned above, the difference of antennal ornamentation was reported (Korovchinsky, 1992, 1998). That was, the populations from the tropical region had a thin seta on the antennal basipod, while those from the north had a small spine. It was believed to be come from the wide distribution of the species (Korovchinsky, 1998).

Korean materials were well accorded with those of other countries reported recently (Korinek, 1987; Korovchinsky, 1992, 1998). However investigating Korean populations, a noticeable characteristic feature that the swimming antennae had a thin seta instead of a small spine on the outer distal side of antennal basipod was found at every materials examined. Referring to the previous reports by Korovchinsky (1992, 1998), it was an unexpected result. The present authors examined this by the comparison with other countries based on the literature (Ueno, 1927; Manuilova, 1964; Chiang and Du, 1979; Korinek, 1987; Mizuno and Takahashi, 1991; Korovchinsky, 1992, 1998). However precise aspects could not be known because the antennal ornamentations were overlooked in China and Japan (Ueno, 1927; Chiang and Du, 1979; Mizuno and Takahashi, 1991). It was found that two types regarding the antennal ornamentations probably co-occur in Russian Far East (Korinek, 1987). Korinek (1987) distinctly figured the presence of an thin seta on the outer distal side of antennal basipod, while he described a thin, flagelliform subapical spine in his revision of the species based on the Russian materials including the type specimens. It was a different result from another work based on the type specimen by Korovchinsky (1992). It is supposed to be that two types of individuals were mixed up in the type materials from Russian Far East. Accepting both the results by Korinek (1987) and Korovchinsky (1992), it could be suggested that the difference on the antennal ornamentation is a variation regardless of the latitudinal distribution, or the variation randomly found from the populations in northern region. However, the stability of this difference needs further study because the detailed informations are still not known in many countries and regions.

*D. dubium* is one of the most common species among cladocerans in lake waters, reservoirs and rivers in Korea. It is a true plankton, and much prefers large waters to small ones. It could be found throughout all seasons except the period of freezing. Individuals of the species often swarm in large



water bodies such as reservoirs and rivers in warm season.

## ACKNOWLEDGEMENTS

This study was supported by research funds from KOSEF (no. 961-0508-065-2).

## REFERENCES

- Chiang, S. C. and N. S. Du, 1979. Fauna Sinica. Crustacea. Freshwater Cladocera. Science Press, Peking, China, 297pp. (in Chinese).
- Frey, D. G., 1973. Comparative morphology and biology of three species of *Eurycercus* (Chydoridae, Cladocera) with a description of *Eurycercus macracanthus* sp. nov. Int. Revue ges. Hydrobiol., **58**: 221-267.
- Kim, I. H., 1988. Key to the Korean freshwater Cladocera. Korean J. Syst. Zool., Special Issue, **2**: 43-65 (in Korean).
- Korinek, V., 1987. Revision of three species of the genus *Diaphanosoma* Fischer, 1890. Hydrobiologia, **145**: 35-45.
- Korovchinsky, M. M., 1992. Guide to the Identification of the Microinvertebrates of the Continental Waters of the World. Sididae and Holopedidae (Crustacea: Daphniiformes). SPB Academic Publ., 82pp.
- Korovchinsky, M. M., 1995. Redescription of *Diaphanosoma volzi* Stingelin, 1905 (Crustacea: Daphniiformes: Sididae) with remarks on comparative morphology, biology and geographical distribution. Hydrobiologia, **315**: 189-201.
- Korovchinsky, M. M., 1996. How many species of Cladocera are there? Hydrobiologia, **321**: 191-204.
- Korovchinsky, M. M., 1998. Revision of the *Diaphanosoma modogliani*-*Diaphanosoma dubium* species group (Crustacea: Ctenopoda: Sididae), with description of a new species from Tropical Asia. Hydrobiologia, **361**: 113-123.
- Korovchinsky, M. M. and I. M. Mirabdullaev, 1995. A new species of the genus *Diaphanosoma* Fischer, 1850 (Crustacea: Daphniiformes: Sididae) from Central Asia and China. Hydrobiologia, **304**: 235-242.
- Manuilova, E. F., 1964. Veviatousye Rachki Fauny SSSR (Cladocera). Nauka Publ. Moscow, 326pp.
- Mizuno, T. and E. Takahashi, 1991. An Illustrated Guide to Freshwater Zooplakton in Japan. Tokai Univ. Publ., 532pp. (In Japanese).
- Ueno, M., 1927. The freshwater Branchiopoda of Japan I. Mem. Coll. Sci. Kyoto Imp. Univ., Ser B, **2**: 259-311.
- Ueno, M., 1941. Introductory account of the biological survey of inland waters of Northern Tyosen (Korea). Jap. J. Limnol., **11**: 96-107 (in Japanese).
- Yoon, S. M. and H. S. Kim, 1987. A systematic study on the freshwater Cladocera from Korea. Korean J. Syst. Zool., **3**: 175-207 (in Korean).

RECEIVED: 9 March 2000

ACCEPTED: 11 April 2000

한국산 긴꼬리물벼룩속(새각강, 즐지목, 긴꼬리물벼룩과)의 분류학적 검토와  
긴팔긴꼬리물벼룩(*Diaphanosoma dubium*)의 재기재

윤 성 명\* · 김 원

(\*조선대학교 사범대학 생물교육과; 서울대학교 자연과학대학 분자생물학과)

요 약

1978년 5월부터 1999년 6월까지 남한의 76개 지소의 다양한 담수역에서 채집된 표본들에 근거하여 긴팔긴꼬리물벼룩(*Diaphanosoma dubium* Manuilova)을 재기재하였으며, 한국에서의 긴꼬리물벼룩속 종들의 과거 기록들을 검토하였다. 이 종은 최근까지 극동아시아 지역에서 *Diaphanosoma brachyurum* Lieven 및 *Diaphanosoma leuchtenbergianum* Fischer와 분류학적으로 혼동되었거나 오동정되었던 종이다. 본 종은 머리부위가 크고 머리의 뒷부분이 솟은 모양이며, 큰 제2촉각을 가지고 있고, 제2촉각의 바닥마디 바깥 면에 얇은 강모가 있으며, 갑각의 뒤쪽 말단에 가시가 없고, 갑각의 배-뒤쪽 가장자리에 배열되어 있는 이빨들의 수가 적다는 점에서 근연종들과 구별된다.

## APPENDIX

### Station list

Seoul: sta 1, Han-gang at Han-gang bridge, May 29, 1978, K.S. Lee; sta 2, Söckch'onho, Chamshil, Apr. 13, 1986.

Inch'ön: sta 3, Söp'ori reservoir, Töckhök-myön, Ongjin-gun, May 6, 1988, C.B. Kim.

Kyönggi-do: sta 4, Kwanggyo reservoir, Suwön-shi, Jul. 19, 1986; sta 5, Pugok reservoir, Suwön-shi, Nov. 2, 1983, C.Y. Chang; sta 6, Mulwang reservoir, Kunp'o-shi, Nov. 8, 1983, C.Y. Chang; sta 7, Han-gang at Yangsu-ri, Yangsö-myön, Namyangju-shi, Aug. 11, 1991; sta 8, Han-gang at Paldang-ri, Wabu-üp, Namyangju-shi, Jul. 18, 1994.

Kangwön-do: sta 9, Üiamho, Ch'unch'ön-shi, Sep. 13, 1986, I.H. Kim; sta 10, Kongjich'ön, Ch'unch'ön-shi, Aug. 16, 1990; sta 11, P'aroho, Gandong-myön, Hwach'ön-gun, Sep. 14, 1986; sta 12, Soyangho, Oct. 16, 1986; sta 13, a swamp near Songjiho, Kosöng-gun, Jul. 18, 1986, I.H. Kim; sta 14, Chukhön reservoir, Kangrüng-shi, Oct. 25, 1985, I.H. Kim; sta 15, a stream at Yongp'yöng, Hönggye-myön, Pyöngch'ang-gun, Jun. 26, 1986, I.H. Kim; sta 16, Changrüng reservoir, Yöngwöl-üp, Yöngwöl-gun, Sep. 16, 1986, I.H. Kim.

Ch'ungh'öngbuk-do: sta 17, Ch'ilsüng reservoir, Koesan-gun, Sep. 13, 1984, C.Y. Chang; sta 18, Goesanho, Koesan-gun, Sep. 13, 1984, C.Y. Chang; sta 19, Mugükji, Ümsöng-gun, Jul. 13, 1986, S.S. Lee; sta 20, Myöngamji, Ch'öngju-shi, Sep. 13, 1984, C.Y. Chang.

Ch'ungh'öngnam-do: sta 21, Kapsa resevoir, Kyeryong-myön, Kongju-shi, Jul. 28, 1988, C.Y. Chang; sta 22, Wölam stream, Kyeryong-myön, Kongju-shi, Jul. 16, 1990, C.Y. Chang; sta 23, Nosöng stream, Kümday-ri, Nosöng-myön, Nonsan-shi, Aug. 25, 1990, C.Y. Chang; sta 24, Ansö reservoir, Ch'önan-shi, Sep. 12, 1992; sta 25, Sapgyoho, Oct. 6, 1985; sta 26, Taeho, Hwagok-ri, Taesan-myön, Sösan-gun, Aug. 2, 1986; sta 27, Ilho reservoir, Wönbuk-myön, Tae'an-gun, May 24, 1996; sta 28, Anhüng reservoir, Künhüng-myön, Tae'an-gun, Jul. 30, 1986, I.H. Kim; sta 29, Chisökri reservoir, Yesan-üp, Yesan-gun, Jul. 2, 1988, J.S. Shin; sta 30, Ch'önjangho, Chöngsan-myön, Ch'önyang-gun, Jun. 26, 1991, C.B. Kim; sta 31, Chuhang reservoir, Sö-myön, Söch'ön-gun, Jul. 31, 1986, C.Y. Chang; sta 32, Küm-gang at Hwang-sannaru, Kanggyüng-üp, Kanggyöng-gun, C.Y. Chang.

Chöllabuk-do: sta 33, Wanggung reservoir, Wanggung-myön, Iksan-shi, May 3, 1988, C.Y. Chang; sta 34, Kümma reservoir, Kümma-myön, Iksan-shi, May 3, 1988, C.Y. Chang; sta 35, Sasan reservoir, Sangsö-myön, Puan-gun, Aug. 18, 1986, I.H. Kim; sta 36, Ch'önggho reservoir, Hasö-myön, Puan-gun, Aug. 18, 1986, I.H. Kim; sta 37, Kaeamsa reservoir, Puan-gun, Aug. 18, 1986, I.H. Kim.

Kwangju: sta 38, Kakhwa reservoir, Puk-gu, Oct. 7, 1995.

Chöllanam-do: sta 39, Pulgap reservoir, Pulgap-myön, Yönggwang-gun, Jul. 19, 1990; sta 40, Kwangjuho, Kosö-myön, Tamyang-gun, Oct. 16, 1995; sta 41, Shinp'o reservoir, Wanggok-myön, Naju-shi, Jul. 3, 1984, C.Y. Chang; Sta 42, Yöngsan-gang, Mongt'an bridge, Muan-gun, Apr. 28, 1997; sta 43, Pokryong reservoir, Ilno-myön, Muan-gun, Jul. 4, 1984, C.Y. Chang; sta 44, Osan reservoir, Kogun-myön, Chindo-gun, Nov. 1, 1994; sta 45, Namsan reservoir, Chindo-üp, Chindo-gun, Nov. 1, 1994; sta 46, Hoidong reservoir, Kogun-myön, Chindo-gun, Jun. 4,

1996; sta 47, Sach'ŏn reservoir, Ŭishin-myŏn, Chindo-gun, Nov. 1, 1994; sta 48, Udul reservoir, Haenam, Jul. 7, 1986, I.H. Kim; sta 49, a pond at Wando Fishery High School, Wando-ŭp, Wando-gun, Jul. 8, 1986, I.H. Kim.

Kyŏngsangbuk-do: sta 50, a pond at Kang-dong, Yŏngju-shi, Jul. 4, 1986, I.H. Kim; sta 51, Andongho, Jul. 4, 1986; sta 52, Kaŭm reservoir, Ŭisŏng-gun, May 26, 1988, C.Y. Chang; sta 53, Taewŏn reservoir, Sŏsan-gun, May 26, 1988, C.Y. Chang; sta 54, Munch'ŏn reservoir, Chinryang-myŏn, Kyŏngsan-shi, Sep. 20, 1996; sta 55, Kŭmho-gang, Kŭmho-ŭp, Yŏngch'ŏn-shi, Jun. 19, 1999; sta 56, Yŏngch'ŏnho, Chayang-myŏn, Yŏngch'ŏn-gun, May 26, 1988, C.Y. Chang; sta 57, Yongyŏn reservoir, P'ohang-shi, May 27, 1988, C.Y. Chang.

Pusan: sta 58, Naktong-gang at Noksan-dong, Kangsŏ-gu, Aug. 10, 1987, M.O. Song; sta 59, Naktong-gang at Ŭsuk Is., Aug. 10, 1987, M.O. Song.

Kyŏngsangnam-do: sta 60, Myŏngdong reservoir, Ch'angnyŏng-ŭp, Jul. 5, 1986, I.H. Kim; sta 61, Up'onŭp, Ibang-myŏn, Ch'angnyŏng-gun, Jun. 26, 1988, M.O. Song; sta 62, Magonŭp, Changma-myŏn, Ch'angnyŏng-gun, Jul. 22, 1987; sta 63, Pŏngaenŭp, Changma-myŏn, Ch'angnyŏng-gun, Jul. 22, 1987; sta 64, Chuksanri reservoir, Sudong-myŏn, Hamyang-gun, Sep. 21, 1996; sta 65, a stream at P'ŏngdang-ri, Chingyo-myŏn, Hadong-gun, Jul. 3, 1984, G.S. Min; sta 66, Songwŏn reservoir, Chingyo-myŏn, Hadong-gun, Jul. 3, 1984, G.S. Min; sta 67, Nam-gang, Chinju-shi, Jun. 24, 1984, G.S. Min; sta 68, Taega reservoir, Taega-myŏn, Kosŏng-gun, Aug. 21, 1987; sta 69, Chilnalnŭp, Pŏpsu-myŏn, Haman-gun, Jul. 6, 1986, I.H. Kim; sta 70, Sannam reservoir, Tong-ŭp, Ch'angwŏn-shi, Jul. 22, 1987; sta 71, Chunam reservoir, Tong-ŭp, Ch'angwŏn-shi, Jul. 22, 1987; sta 72, Tongp'angemot, Tong-ŭp, Ch'angwŏn-shi, Jul. 22, 1987; sta 73, Ugok reservoir, Chinyŏng-ŭp, Ch'angwŏn-shi, Jul. 22, 1987; sta 74, Panggimot, Samnam-myŏn, Ulsan-shi, Aug. 14, 1994.

Cheju-do: sta 75, a stream at Nohyŏng-dong, Cheju-shi, Oct. 20, 1995, C.Y. Chang; sta 76, a swamp at Mara Is., Oct. 25, 1991, C.Y. Chang.